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AN INTERACTIVE GRAPHICS PROGRAM FOR MANIPULATION
AND DISPLAY OF PANEL METHOD GEOMETRY

Jon F. Hall, Dan H. Neuhart, and Kenneth B. Walkley

KENTRON INTERNATIONAL, INC.
Kentron Technical Center
Hampton, Virginia 23666

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SUMMARY

Modern aerodynamic panel methods that handle large, complex geometries have made evident the need to interactively manipulate, modify, and view such configurations. With this purpose in mind, the GEOM program has been developed. It is a menu-driven, interactive program that uses the Tektronix PLOT 10 graphics software to display geometry configurations which are characterized by an abutting set of networks. These networks are composed of quadrilateral panels which are described by the coordinates of their corners.

GEOM is divided into fourteen executive-controlled functions. These functions are used to build configurations, scale and rotate networks, transpose networks defining M and N lines, graphically display selected networks, join and split networks, create wake networks, produce symmetric images of networks, repanel and rename networks, display configuration cross sections, and output network geometry in two formats. A data base management system is used to facilitate data transfers in this program.

The user is assumed to have a basic geometry file prepared for input to the program. This geometry may then be displayed, manipulated, or expanded using the various GEOM functions. A sample session illustrating various capabilities of the code is included as a guide to program operation.

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INTRODUCTION

Recent advances in aerodynamic panel method computer programs such as PAN AIR (ref. 1) have pointed to the need to manipulate and modify, in an interactive environment, the elementary networks which describe a component of a configuration to the analysis code. To this end, a new program called GEOM has been developed to perform certain elementary network manipulations and to display the results graphically. Functions available through GEOM include generalized three-dimensional transformations, repanelling, joining, splitting, and symmetric component generation for networks. In addition, a post processing option automatically produces hard copies of the displays generated during program execution including orthographic projections of the geometry with hidden lines removed.

Although GEOM was developed with PAN AIR-type geometry requirements in mind, it is not exclusively limited to the PAN AIR geometry format. GEOM can manipulate any type of geometry that can be expressed in the Hess formatted data structure described in reference 2.

Version 1.0 of GEOM is a menu-driven interactive computer program written in FORTRAN IV. It uses the TEKTRONIX PLOT 10 graphics package for visual displays. Geometry management and I/O operations are performed with the PAGMS (PAN AIR Geometry Management System) data management system described in reference 3. Although GEOM currently runs only on CDC Cyber computers using the NOS 1.4 operating system, the program has been modularly designed for efficient adaptation to other machines. Optimized buffer lengths, efficient I/O, and strict core management provide for a highly responsive interactive environment.

This report is intended to serve as a user's guide for GEOM. Each module function is described along with the various options and execution sequences available. A sample interactive session is also included.

The authors would like to acknowledge the work of Carl Freeman of the United States Army whose development of an earlier geometry program motivated the effort described in this report.

GEOMETRY DEFINITIONS AND CONVENTIONS

Before detailing specific features of GEOM, some background information regarding geometry definitions and conventions is required. These definitions appear frequently in GEOM and allow the user to conveniently describe a configuration and its components. In particular, the concepts of panels, M and N lines, networks, and configuration need to be introduced.

A configuration is composed of a collection of abutting networks, i.e., patches of surface. Thus, a network is usually chosen as a logical portion of a configuration. Each network is composed of an ordered set of quadrilateral panels with each panel being fully described by the x, y, z Cartesian coordinates of its corners. As shown in figure 1, M and N lines are defined by the ordered set of panel corner points. The order in which the network points are specified provides the required discrimination between the M direction and the N direction. For each N line or column, points are input sequentially in the direction of increasing M. These points are then connected to form the rows of the network. All point-to-point connections are made with straight lines. This basic data structure for a network will subsequently be referred to as the Hess format.

To differentiate between the "upper" and "lower" sides of a network, the PAN AIR convention is used. As shown in figure 2, let \hat{N} be a vector that points in the direction of increasing N. Likewise, define the vector \hat{M} for the M direction. Then the vector cross product $\hat{N} \times \hat{M}$ is a vector normal to the network and points outward from the upper surface. The opposite side of the network is then termed the lower surface.

Figure 2 also illustrates the PAN AIR network-edge numbering convention. The first row of points ($M = 1$) defines edge one and the last row is edge three. Similarly, the first and last columns define edges four and two respectively. When viewed from the lower surface, the numbering of the network edges is always in the clockwise direction.

A collection of abutting networks form a piecewise continuous description of a configuration. In the context of program GEOM, a configuration is any set of networks associated for the purposes of graphic display.

GEOM CAPABILITIES

Program GEOM is divided into basic functions that are controlled by an executive routine. At the termination of each user-selected operation, control returns to the executive for selection of another function. This process allows the user to construct complicated geometric processes from a series of simple operations on the input data set.

As shown in figure 3, there are fourteen functions in Version 1.0 of GEOM. For each function there is an associated four letter mnemonic that is recognized by the executive. Keying in a mnemonic causes program execution to transfer from the executive to the selected function. Table I presents a summary of each function currently available in GEOM 1.0. Detailed descriptions of each function are presented in the following sections.

In the function discussions which follow, references are made to the PAGMS data base. This data base is created using the PAN AIR Geometry Management System described in reference 3. Network data input to GEOM is automatically written to the data base. The user selects networks from the data base for graphic display or manipulation via GEOM command functions.

Two types of networks, original and temporary, are stored in the PAGMS data base. The geometry as originally input to the data base is stored in network form under its own name. This name is read from the first record for each network in the input geometry beginning in card column 33. When the network geometry is actually added to the current "working" configuration using the CONF function, temporary networks are created in the data base. Depending on the function performed, the temporary or the original networks are modified in the data base during program execution.

Function CONF

The purpose of the configuration function CONF is to retrieve original networks from the PAGMS data base and make them available as a working set of temporary networks for graphic display or output. The set of networks so selected defines the configuration to GEOM. CONF also allows deletion of specified networks from the currently defined configuration.

Before GEOM can draw or output geometry for a configuration, the defining networks must be selected by keying in the mnemonic CONF while in executive mode. Networks are then selected (or deleted) using the graphics cursor. A temporary network labeled TEMPNETXXX is created on the PAGMS data base for each selected network. XXX is a unique 3-digit identifier. When a network is deleted, the associated TEMPNETXXX network is flagged *DELETED*. It is not necessary to enter the CONF function each time a graphic display or manipulation is desired, as GEOM remembers the last defined configuration. Once a configuration is defined using CONF, an arbitrary sequence of executive functions may be requested without additional CONF entries. If, however, other functions are used which create a new network, CONF must be entered to add this new network to the configuration. A maximum of 40 networks may comprise a configuration.

Function ORDR

The order function ORDR performs any of the following three tasks: transpose M and N lines, reorder M lines, or reorder N lines. Transposing M and N lines means that M lines become N lines and vice versa. Reordering M or N lines reverses the numbering sequence associated with the selected M or N line. This function is useful for the PAN AIR code in that the direction of the surface normals may be easily altered to conform to the desired upper/lower surface conventions. Graphic display of a network normal is available in function DRAW. Note that ORDR operates on the original network data in the data base.

Function COMP

The component function COMP allows the user to perform certain manipulations on the M or N lines of a specified network. Options allow deletion, rotation, scaling, and translation of M and N lines. Additionally, an entire network can be deleted from the currently defined configuration. All COMP options allow the user to replace the existing component with the manipulated component or add the manipulated component to the data base with a new identification.

Function DRAW

The graphic display function DRAW is used to draw the defined configuration in several different ways as specified by user input. A standard three-view layout

may be requested, an orthographic view may be displayed, or arbitrary cross sections, obtained by passing a series of cutting planes through the geometry, may be drawn. Options are available to draw the M and N lines as solid or dashed lines, to draw only the network edges, to number the M or N lines or network edges, and to draw the surface normals.

If the three-view option is selected, an additional option is presented which allows the user to specify a partial section to be displayed. Configuration minimum and maximum x, y, z coordinates are listed, and the user specifies minimum and maximum coordinates to be displayed. This option is very useful for looking at an isolated portion of a configuration (e.g., a wing-body intersection) without plotting the complete geometry. Note, however, that arbitrary-cross-sections should be displayed using the arbitrary cross-section option and not by specifying identical coordinates in a given direction under the partial-section option.

When the orthographic option is selected, the user may specify rotation of the configuration about an arbitrary point with subsequent viewing from a specified point. Once the configuration is displayed on the screen, additional options are available to zoom in or out on an area specified using the graphics cursor, display exploded views of the various networks, or remove hidden lines. When the hidden line option is selected, the program will create a geometry data file for post processing by a separate program. This post-processing job is initiated by an internally-created control card file that is automatically submitted by GEOM for batch processing. The post-processing program results in VARIAN plots as well as a user plot vector file (PLTXXXX) which is saved and may be displayed interactively at a later time using the Tektronix postprocessor available at NASA-Langley. The Tektronix postprocessor automatically reads the plot vector file after it has been accessed and given the name SAVPLT.

Arbitrary cross sections may be displayed one at a time, or several plots may be overlaid. Three points are input by the user to fully describe the desired cutting plane. Additional planes may be specified individually, or a uniform spacing option may be selected. The exact planes selected may be previewed prior to cross section display.

Function JOIN

The network joining function JOIN allows the user to connect two networks along specified edges. The cursor is placed over the appropriate boxes on the JOIN menu, and the edge numbers at which joining is to take place are keyed in. The user has the option to discard one or both of the adjoining edges or to keep both. For example, if the lower and upper surfaces of a wing are joined at the leading edges, one would generally delete one of the edges so as not to have a redundant M-line. The joined geometry is saved under a new name on the PAGMS data base as a new component. This component must be added in the CONF function in order for it to be displayed by the DRAW function.

Function WAKE

The wake creation function WAKE adds one of two possible wake networks to a configuration. The user must specify the downstream x-coordinate at which the wake will terminate before entering the WAKE menu. In the menu, the user first keys in the wake type (A or B). Wake type A is generally located downstream of a lifting surface. It consists of a spanwise set of N lines that match the location of those on the lifting surface to which it abuts. Wake type B is typically located aft of a non-lifting body and consists of four edges formed by two N lines and two M lines (four points). Type B also can provide wake surface continuity between a fuselage and the wake of a lifting surface or between two wake networks. Figure 4 shows these two wake types. After the wake type is selected, the user must select the network and the edge number from which the wake will be shed. The wake network will appear on the PAGMS data base as a new component with a unique identifier. It must be added to the configuration in function CONF before it can be displayed using DRAW.

Function CATL

The file catalog function CATL produces a catalog listing of panel data on the PAGMS database file. The name of this file is specified by the user at the beginning of the program. The catalog listing gives information on whether a network is active or deleted, and the number of N-lines, M-lines, and panels per network. In addition, block type, which indicates the length of the data storage unit, is shown. Various configuration totals are given at the bottom of the listing.

Function SYMM

The symmetry function SYMM creates the X-Y or X-Z symmetric image of a specified network. This is accomplished by specifying 1 or 2 (X-Z or X-Y symmetry) with the cursor in the menu selection. The image network will appear in the catalog as a separate component with a unique identifier. It must be added in the CONF function before it can be displayed in DRAW.

Function HESS

The geometry output function HESS places selected network geometry in HESS format on a user-specified file. This will be a local file that must be saved after program termination if the user wishes to keep the geometry for later use. The HESS geometry format is 3F10.5, one point per card. In addition, card column 31 contains a flag indicating the first point of a new network (FLAG = 2) or the first point of a new N-line (FLAG = 1). The flag in card column 32 indicates whether the network represents a lifting or non-lifting surface (FLAG = 1 or 0, respectively). Network title information is supplied after the second flag.

Function PANR

The geometry output function PANR writes selected network geometry in PAN AIR format to a user-specified file. This local file must be saved after program termination if the user wishes to keep the geometry for later use. The PAN AIR geometry format is 6F10.5, two points per card. In addition, appropriate network title records and boundary condition information is supplied. This file may be combined with other required PAN AIR data cards and used directly as input to the PAN AIR program.

Function SPLT

The function SPLT splits a network into two networks along a specified M or N line. The program supplies information about the number of M and N lines and which are valid for use in splitting a network. New networks are created on the data base and user-supplied names are requested. These new networks must be added to the configuration in CONF before they can be viewed in DRAW.

Function RPNL

The network repanelling function RPNL repansels a network in the M and/or N direction with a uniform, cosine, or user-specified spacing scheme. The user specifies any stationary M or N lines and the desired number of lines in the repanned network. Splines under tension are used for interpolating the points. The user has the option of specifying whether the spline used approaches a cubic spline (spline tension factor $\sigma = 0$) or a piecewise linear interpolation ($\sigma \geq 25$). The repanned network replaces the original network or is saved as a new component with a unique identifier in the data base.

Function NAME

The function NAME allows the user to rename menu-selected networks. These names are applied directly to the existing networks on the data base, and to the current configuration where appropriate, and do not create new networks.

Function STOP

The function STOP terminates program execution. It may do some graphics post processing if previously requested by the user. Batch-submitted hidden line plots may be requested in the DRAW function, or the entire GEOM session may be saved on a plot vector file for post processing. Local files containing geometry output must be saved by the user if they are needed for use after terminating the interactive session.

ACCESSIONG AND EXECUTING GEOM

The GEOM executable program is stored under user number, UN=642917C, as the absolute binary indirect access file GEOMABS. Before executing GEOM, the user should have a "Hess-type" geometry file available as a local file, an indirect access permanent file, or a direct access permanent file. Alternatively, a PAGMS-type binary file created from a previous GEOM session may be input.

The following interactive commands will access and initiate execution of GEOM:

/GET,GEOMABS/UN=642917C.
/GEOMABS.

SAMPLE INTERACTIVE SESSION

A sample interactive GEOM session is presented in figures 5 through 24. Although all possible options and suboptions are not shown, a general idea of the operation of the program can be obtained by examining the sample session.

Figure 5 shows the sample configuration. It consists of a two-network wing, wing tip, fin, fin tip, and multi-network fuselage and inlet.

Figure 6a shows the initiation of a GEOM session. After initiating execution by entering "GEOMABS", the user responds to several basic questions. Note that negative responses have been entered using the letter "N." A simple carriage return also specifies the negative response. The user may specify a desire to save the plot vector file containing the entire interactive session either for hard copy plots or viewing after the session is terminated. Figure 6b displays questions about the user's input geometry data. If there does not exist a PAGMS geometry file from a previous GEOM session, then a new PAGMS file is opened. The "Hess-type" file is then read in and the data entered on the user-named PAGMS file NEWFILE. The executive program section is then entered as shown in figure 6c, and one of the fourteen funtions is chosen.

The first function that should be chosen is CONF. This will make the geometry available for use by the other functions. The CONF menu is shown in figure 7. The cursor on the terminal display will appear and when placed over the appropriate box, the desired letter (see upper left corner) should be keyed in. All networks may be added by keying in "A" in the "ALL NETWORKS" box in the upper right corner. Otherwise, individual networks may be added or deleted by placing the cursor over the appropriate box and keying in the appropriate letter. When all of the desired networks have been added to the configuration, an "R" should be keyed in over the "RETURN TO GEOM EXECUTIVE" box. This will allow the user to again choose from the fourteen available executive functions.

When the COMP function is chosen, the menu shown in figure 8 appears. In order to select a network for manipulation, the cursor is placed over the appropriate box and an "S" is keyed in. Questions will then be asked concerning the type and magnitude of manipulation desired. Similarly, to de-select, and delete and recover networks from the database, the appropriate letter should be keyed in over the box corresponding to the desired network. Return to the executive is made by keying in a "Q" over the "QUIT COMPONENT SELECTION" box.

The DRAW function does not display a menu but asks questions, as shown in figure 9. For example, a three-view drawing of the configuration with only the network edges shown and with three-view frames is given in figure 10. Responses required to draw an orthographic projection with N and M lines solid, and using the default viewpoint, are shown in figure 11. The resulting drawing is shown in figure 12. A drawing with only network edges, surface normals, and network numbers is shown in figure 13a. An exploded view of that same configuration is shown in figure 13b.

Arbitrary cross sections of the configuration may be drawn, and the appropriate questions and responses are shown in figure 14. Multiple cuts plotted on a single frame are requested in this case. In addition, the default spline tension factor and cutoff angle are specified indicating a nearly cubic spline between break points, which are determined using the default cutoff angle. Adjacent line segments on the cross-sectional curve, whose relative angle exceeds the cutoff angle, have a common point designated as a break point. The subsequent splines are drawn on either side of these points but not through them. The cutting plane is defined by three points. The first point defines the vertex of two vectors originating at that point. The following two points define the vectors \vec{A} and \vec{B} , where $\vec{A} \times \vec{B}$ points in the direction of subsequent cuts when multiple sections cuts have been specified. In that case, the user must supply information concerning the number of cuts and their spacing. The user can preview the section cut locations as shown in figure 15. The multiple section cuts are plotted in figure 16.

The choice of two networks to be joined using the JOIN function is made using the menu illustrated in figure 17a. In the box for each network, the edge at which the network is to be joined is keyed in. In this example, the leading edges of the two wing surfaces (upper and lower) are to be joined. The user is then presented

with the options to discard one or both of the adjoining edges or to keep them both, as shown in the left hand side of figure 17b. This would be useful, for example, in deleting one of the redundant wing leading edges. The joined geometry is stored in the data base under a new name.

Wakes can be generated as shown in figure 18a. The user must be prepared to specify the downstream edge from which the wake will be shed. For example, a wing with a leading edge number one, will have a wake shed from edge number three - the trailing edge. Figure 18b shows the WAKE menu. The type of wake (A or B) must first be entered in the box in the upper right hand corner. Type A and B wakes are generally for lifting and non-lifting networks, respectively. (This follows the usual PAN AIR representation.) The edge number from which the wake will be shed is then keyed in over the box for the appropriate network. The configuration with the wake added is plotted in figure 19.

An example of the catalog listing of data on the PAGMS file is given in figure 20. Note that WING03 at the bottom of the list (the joined wing network) exists but has not been added to the working configuration by function CONF as evidenced by the non-existance of a corresponding TEMPNET data files.

The joined wing network, WING03, is split into 2 networks using the SPLIT function, as shown in figure 21. The two new networks formed by splitting along an N line are given unique names and exist as new networks in the data base.

When a network is chosen for repanning using the RPNL function, the procedure outlined in figure 22 is followed. The user may change the distribution of M and N lines as shown in figures 22a and 22b, respectively. In the case of user-specified spacing, the user must indicate any N or M lines that need to remain fixed as, for example, in the case of a wing N line at a planform breakpoint. The repanned network is given a unique name in the data base.

The execution of the network renaming function, NAME, is illustrated in figure 23. The user-input new name replaces the old name in the data base.

The user terminates the GEOM session using the function STOP. If the plot vector file for the entire session was requested to be saved, the program can

initiate a plot job, as shown in figure 24. Otherwise, the program simply terminates. The local files existing after session termination are shown in figure 24. File NEWFILE is the PAGMS data base file containing the configuration as it existed at program termination. SEEPVF is a file that is used during execution and is of no interest to the user. DEMO is the Hess-type input geometry file. If the user had executed options HESS or PANR, there would exist a user-named output file containing the appropriate geometry. SAVPVF is the session plot vector file. File ZZZZZ32 is a system software generated file that is of no importance to the user.

CONCLUDING REMARKS

The GEOM program, developed in response to the growing complexities of aerodynamic panel method geometries, is a highly user-oriented, interactive program. The ability to modify, manipulate, and display the network geometry of a configuration, using a set of fourteen executive-controlled functions, makes GEOM a valuable tool for preparing a configuration for analysis. GEOM has the capability to perform network creation and modification, data base generation and manipulation, data I/O, and graphic display. These capabilities are suitable for any geometry that can be expressed in the Hess-type data format. The PAGMS data base, into which the input geometry is written, handles geometry management and I/O operations. These GEOM features make it a non-complicated program from the user's point of view and as such should minimize user orientation time.

REFERENCES

1. Carmichael, R. L.; and Erickson, L. L.: PAN AIR - A Higher Order Panel Method for Predicting Subsonic or Supersonic Linear Potential Flows About Arbitrary Configurations. AIAA Paper 1255, June 1981.
2. Halsey, D. N.: A Three-Dimensional Potential Flow Program with a Geometry Package for Input Data Generation. NASA CR 145311, March 1978.
3. Hall, J. F.: PAN AIR Geometry Management System (PAGMS) - A Data-Base Management System for PAN AIR Type Geometry Data. NASA CR 165811, November 1981.

Table I.- GEOM functions, mnemonics, and descriptions.

Function	Mnemonic	Description
Configuration	CONF	Selects from the configuration data base the set of networks to be displayed graphically by the DRAW function or otherwise manipulated by additional function calls.
Order	ORDR	Reverses or transposes the M or N lines of a specified network.
Component	COMP	Manipulates the M or N lines of one or more networks, e.g., rotate, translate, scale, delete.
Draw	DRAW	Graphically displays the networks selected in CONF. Generates a standard three-view or an orthonormal view of arbitrary orientation, or views of arbitrary cross sections.
Join	JOIN	Joins two networks at specified edges to form a single network.
Wake	WAKE	Creates a wake network by specifying the network and edge number from which wake is shed.
Catalog	CATL	Produces a catalog listing of the networks on the PAGMS data file.

Table I.- Concluded.

Function	Mnemonic	Description
Symmetry	SYMM	Creates the XY- or XZ-plane symmetric complement of a specified network.
Hess output	HESS	Outputs selected network geometry in Hess format to a specified file.
Split	SPLT	Splits a network into two networks along a specified M or N line.
Repanelling	RPNL	Re-pansels a network with specified spacing in the M and/or N direction.
Stop	STOP	Terminates the interactive session and optionally performs some graphics post-processing.
PAN AIR output	PANR	Outputs selected networks in PAN AIR format to a specified file.
Rename networks	NAME	Allows user to rename selected networks.

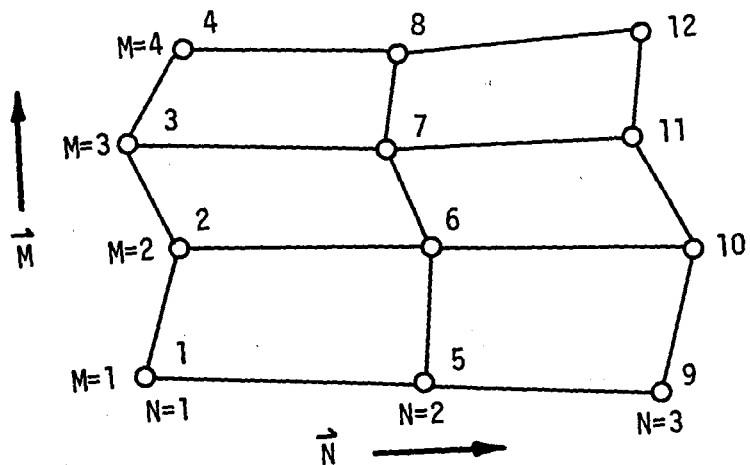


Figure 1. - N and M line definition.

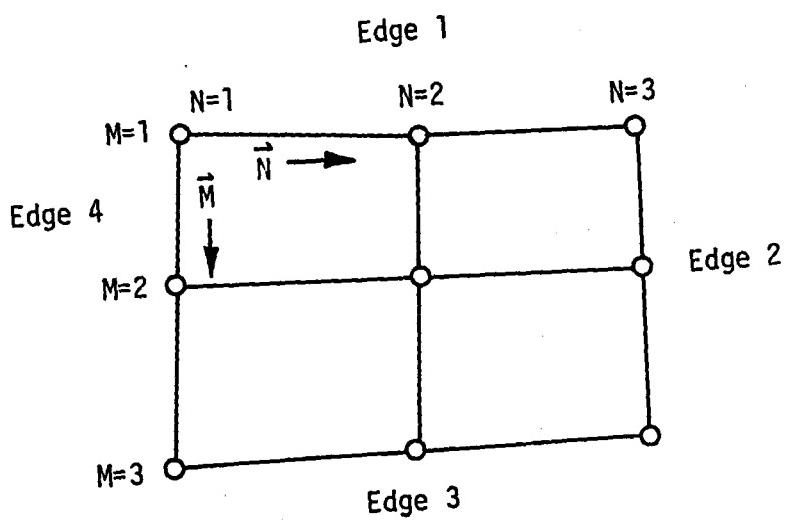


Figure 2. - PAN AIR network convention.

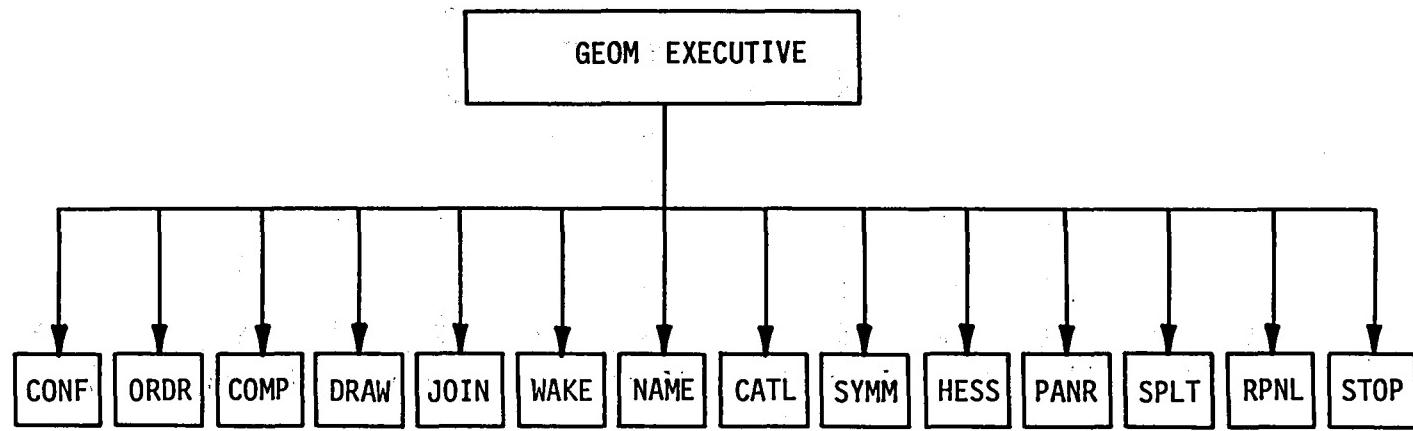


Figure 3. — GEOM executive controller and functions.

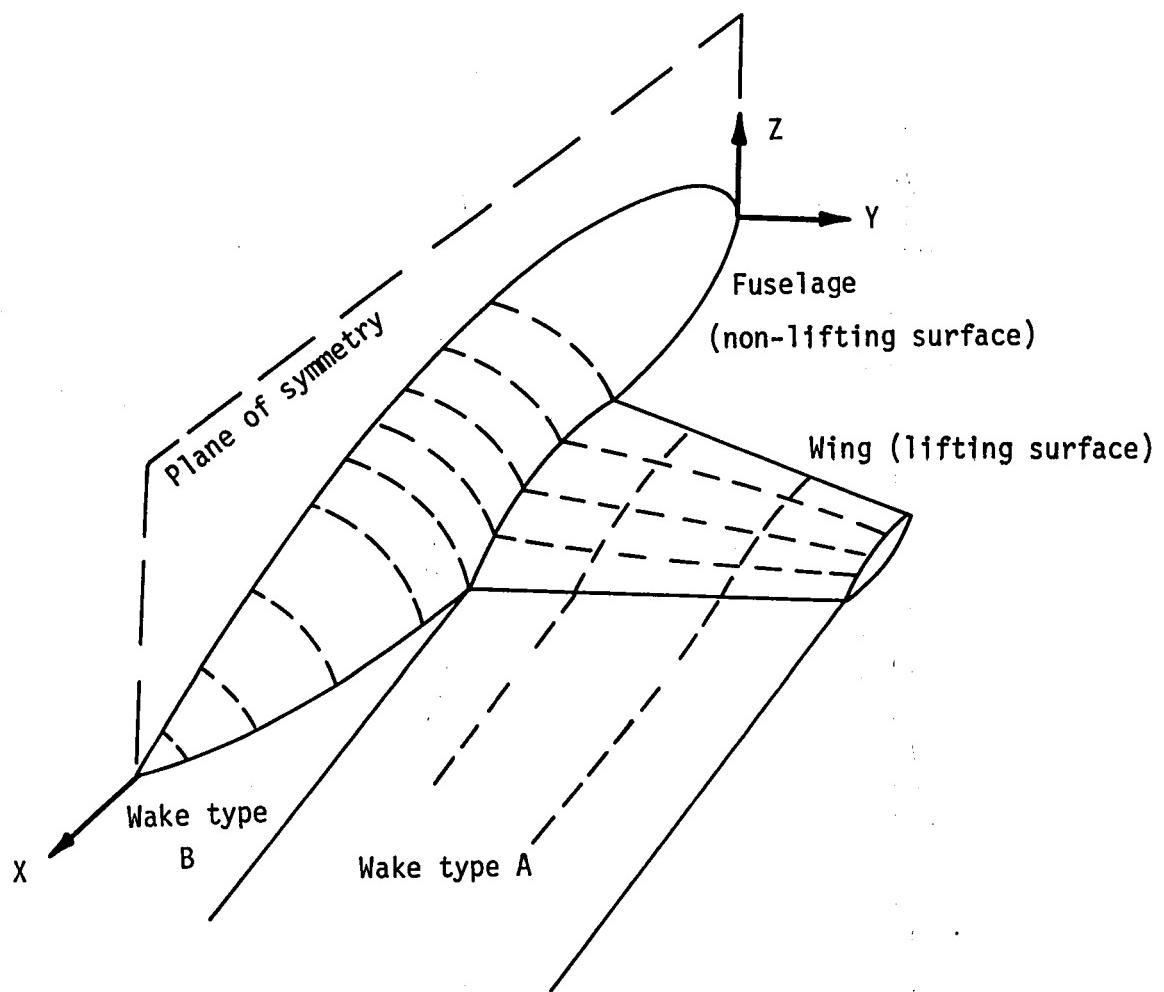


Figure 4.- Wake network types.

KEY IN 1 TO REINSTATE 2 TO ZOOM IN
 3 TO ZOOM OUT 4 TO EXPLODE
 5 TO REMOVE HIDDEN LINES BATCH
 6 TO RETURN TO GEOM EXECUTIVE?

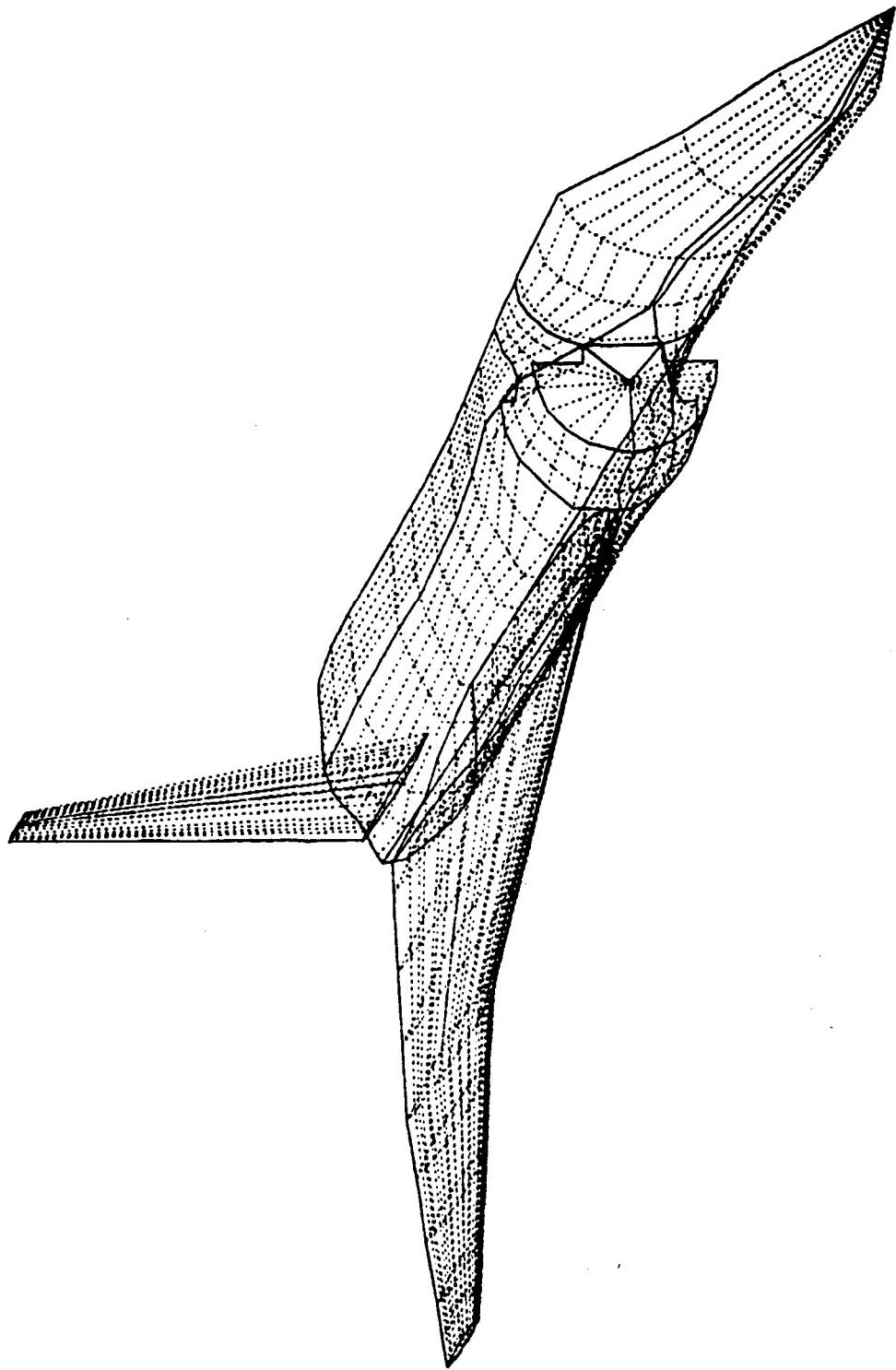


Figure 5.— Sample configuration.

```
INPUT DELIVERY INFORMATION. EG. B1251 JOHN DOE  
? B1251 JOHN DOE  
DID YOU LOGIN WITH A PASSWORD (Y/N)? Y  
ENTER PASSWORD  
?  
DO YOU WANT TO SAVE THE PLOT VECTOR FILE 'SAUPUF'  
IN ANTICIPATION OF GRAPHICS POST PROCESSING? Y OR N  
? N  
DO YOU WISH TO CHANGE CHARACTER SIZE? DEFAULT=3 Y OR N  
? N  
DO YOU WISH TO CHANGE BAUD RATE? DEFAULT=1200 Y OR N  
? N
```

(a) Initiation.

```
DOES ANY OF YOUR INPUT GEOMETRY EXIST ON A "PAGMS"  
TYPE BINARY FILE ? Y OR N  
? N  
INPUT THE NAME OF THE FILE ON WHICH A NEW PAGMS  
DATABASE IS TO BE CREATED ?  
? NEWFILE  
INPUT DATABASE IDENTIFIER/HEADER UP TO 80 CHARACTERS?  
? DEMO GEOMETRY  
PROGRAM GEOM OPENING NEW PAGMS FILE NEWFILE  
DOES ANY OF YOUR INPUT GEOMETRY EXIST ON "HESS" TYPE  
CODED FILES ? Y OR N  
? Y  
INPUT THE "HESS" FILE NAME ?  
? DEMO  
KEY IN 1 FOR LOCAL FILE  
2 FOR INDIRECT ACCESS PERMANENT FILE  
3 FOR DIRECT ACCESS PERMANENT FILE  
"CR" DEFAULTS TO LOCAL FILE  
? 2  
19 NETWORKS/COMPONENTS FOUND ON FILE DEMO  
DO YOU HAVE ADDITIONAL INPUT GEOMETRY ON A "HESS"  
TYPE CODED FILE ? Y OR N  
? N
```

(b) Input geometry file specification.

```
GEOM EXECUTIVE: KEY IN FUNCTION  
CONF ORDR COMP DRAW JOIN WAKE CATL SYMM  
HESS PANR SPLT RPNL NAME STOP  
?
```

(c) Function selection.

Figure 6. - GEOM initialization.

PLACE CURSOR OVER BOX KEY IN A TO ADD NETWORKS D TO DELETE NETWORKS R TO RETURN		CONFIGURATION MENU			
<input type="checkbox"/> A WING01__01	<input type="checkbox"/> A WING02__02	<input type="checkbox"/> A INLT03__03	<input type="checkbox"/> A INLT04__04		
<input type="checkbox"/> A FUS05__05	<input type="checkbox"/> A INLT06__06	<input type="checkbox"/> A FIN07__07	<input type="checkbox"/> A FUS08__08		
<input type="checkbox"/> A FUS09__09	<input type="checkbox"/> A INLT10__10	<input type="checkbox"/> A FUS11__11	<input type="checkbox"/> A FUS12__12		
<input type="checkbox"/> A FUS13__13	<input type="checkbox"/> A FORBD14_14	<input type="checkbox"/> A FORBD15_15	<input type="checkbox"/> A FORBD16_16		
<input type="checkbox"/> A INLT17__17	<input type="checkbox"/> A WINGTIP_18	<input type="checkbox"/> A FINLTIP__19			

Figure 7.- CONF menu.

PLACE CURSOR OVER BOX
KEY IN S-SELECT, X-DE-SELECT
D-DELETE, R-RECOVER
Q-QUIT SELECTION

COMPONENTS

MENU

QUIT COMPONENT
SELECTION

WINGP1__01

FUS05___05

FUS09___09

FUS13___13

INLT17__17

WING02__02

INLT06__06

INLT10__10

FORBD14_14

WINGTIP_18

INLT03__03

FIN07___07

FUS11___11

FORBD15_15

FINTIP__19

INLT04__04

FUS08___08

FUS12___12

FORBD16_16

Figure 8. — COMP menu.

```
KEY IN 1 TO DRAW THREE VIEWS  
2 TO DRAW ORTHOGRAPHIC PROJECTION  
3 TO DRAW ARBITRARY CROSS SECTIONS  
? 1  
KEY IN 1 TO DRAW N-LINES SOLID  
2 TO DPAW M-LINES SOLID  
3 TO DRAW N & M-LINES SOLID  
4 TO DRAW N & M-LINES DASH, NETWORK EDGES SOLID  
5 TO DRAW NETWORK EDGES SOLID  
*CR* DEFAULTS TO 4  
? 5  
MULTIPLE OPTION SELECTION:  
KEY IN 0 TO IGNORE OPTIONS  
1 TO NUMBER N-LINES  
2 TO NUMBER M-LINES  
3 TO NUMBER NETWORK EDGES  
4 TO NUMBER NETWORKS  
5 TO DRAW SURFACE NORMALS  
*CR* DEFAULTS TO 0  
INPUT NUMBERS IN FREE FORMAT. EG. 5, 3,8-6,1 3 = 3,5,6,7,8,13  
OR CARRIAGE RETURN TO QUIT  
?  
DO YOU WISH TO DRAW PARTIAL SECTIONS? Y OR N  
? N  
DO YOU WISH TO ELIMINATE 3UU FRAMES AND LABELS? Y OR N  
? N
```

Figure 9.—Execution of DRAW function to display network edges only.

KEY IN 1 TO REDRAW THIS CONFIGURATION
2 TO RETURN TO GEOM EXECUTIVE
?

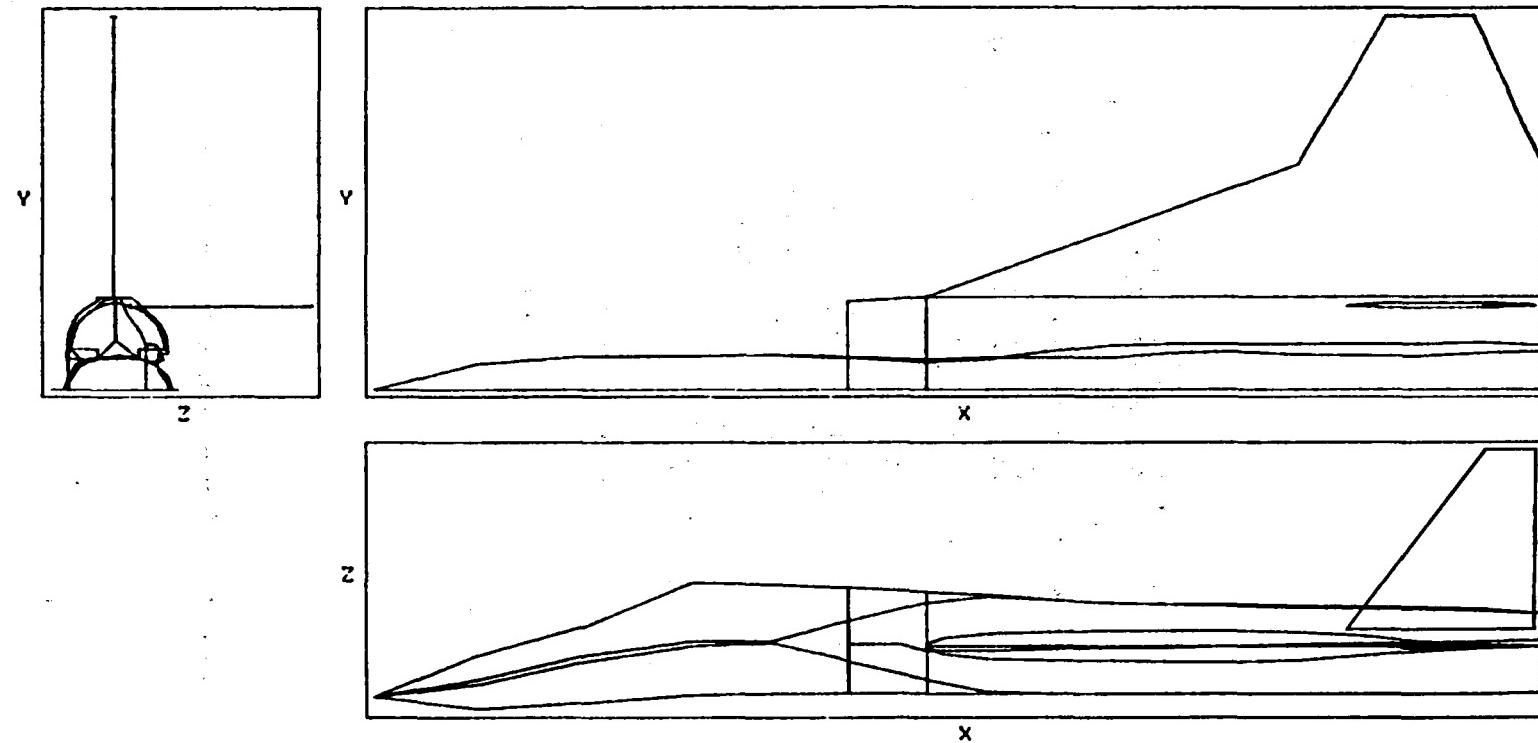


Figure 10.— Drawing of configuration network edges only.

KEY IN 1 TO DRAW THREE VIEWS
2 TO DRAW ORTHOGRAPHIC PROJECTION
3 TO DRAW ARBITRARY CROSS SECTIONS
? 2

KEY IN 1 TO DRAW N-LINES SOLID
2 TO DRAW M-LINES SOLID
3 TO DRAW N & M-LINES SOLID
4 TO DRAW N & M-LINES DASH, NETWORK EDGES SOLID
5 TO DRAW NETWORK EDGES SOLID
"CR" DEFAULTS TO 4

? 3

MULTIPLE OPTION SELECTION:

KEY IN 0 TO IGNORE OPTIONS
1 TO NUMBER N-LINES
2 TO NUMBER M-LINES
3 TO NUMBER NETWORK EDGES
4 TO NUMBER NETWORKS
5 TO DRAW SURFACE NORMALS
"CR" DEFAULTS TO 0

INPUT NUMBERS IN FREE FORMAT. EG. 5, 3,8-6,1 3 = 3,5,6,7,8,13
OR CARRIAGE RETURN TO QUIT

? N

DO YOU WISH TO ROTATE THIS CONFIGURATION? Y OR N

? N

INPUT VIEWPOINT X,Y,Z COORDINATES OR "CR" TO DEFAULT
TO -50000.00 15000.00 10000.00

Figure 11.- User responses required for orthographic display.

KEY IN 1 TO REDRAW 2 TO ZOOM IN
3 TO ZOOM OUT 4 TO EXPLODE
5 TO REMOVE HIDDEN LINES BATCH
6 TO RETURN TO GEOM EXECUTIVE?

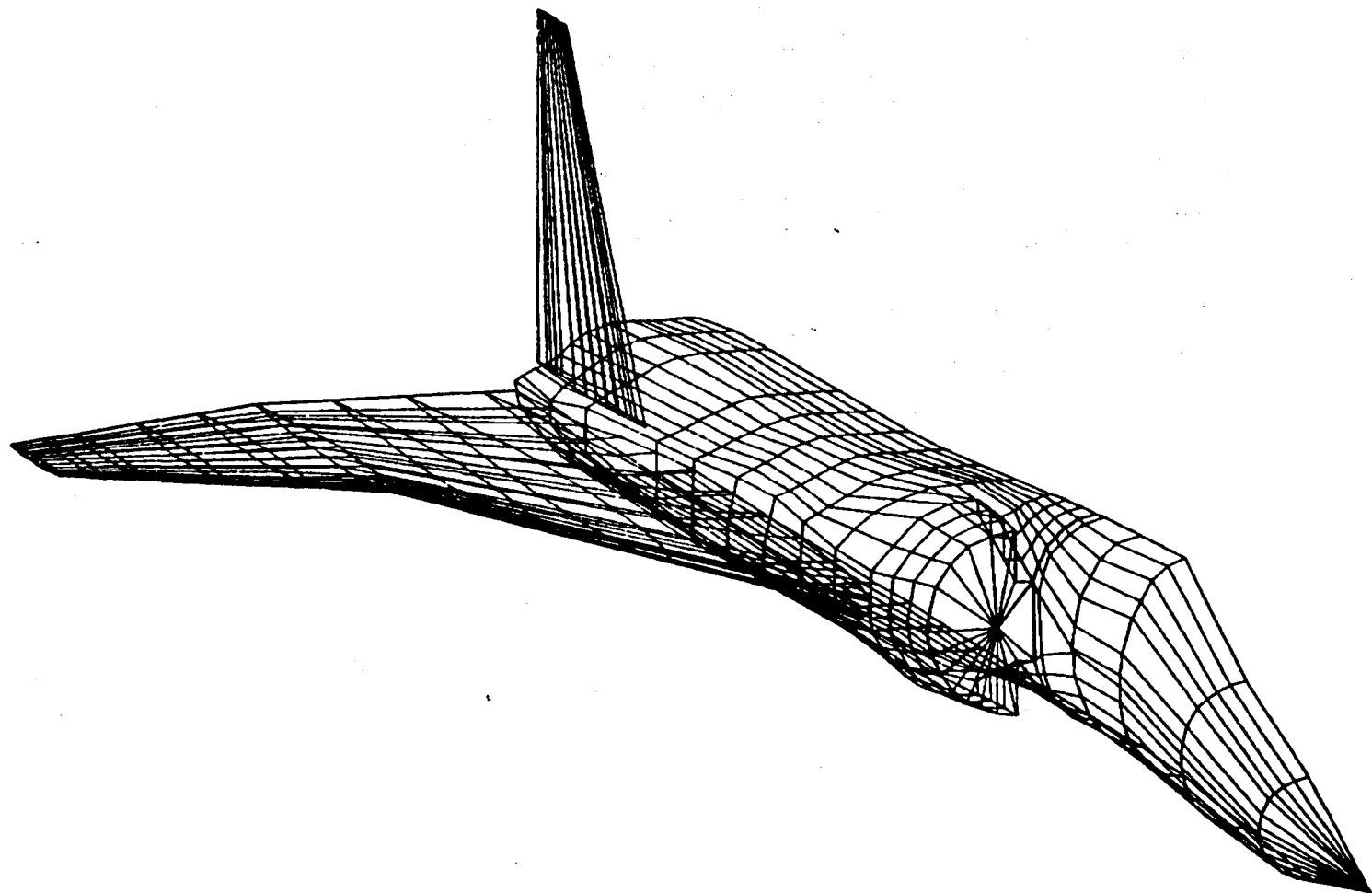
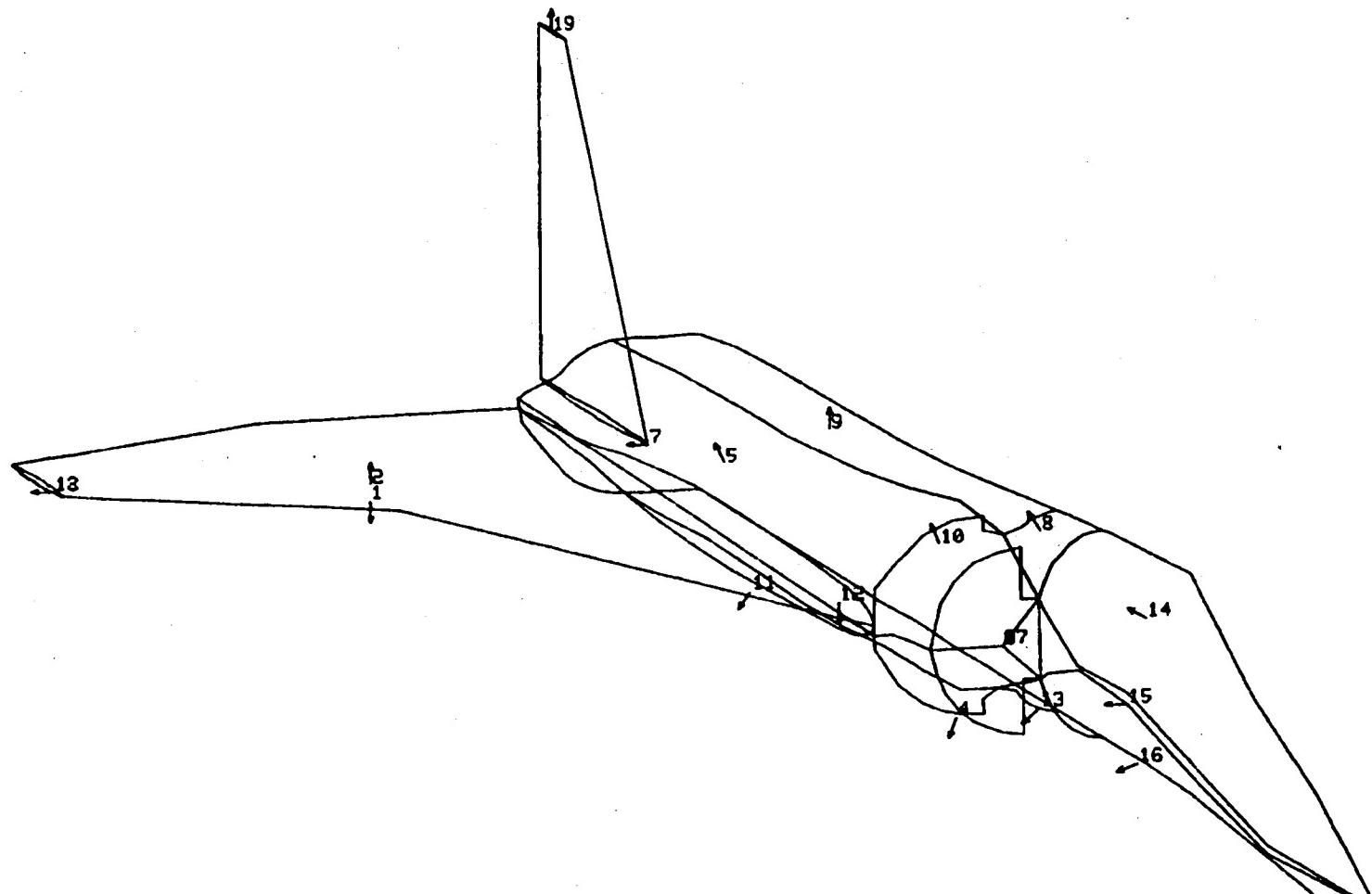


Figure 12.-Orthographic display of configuration.

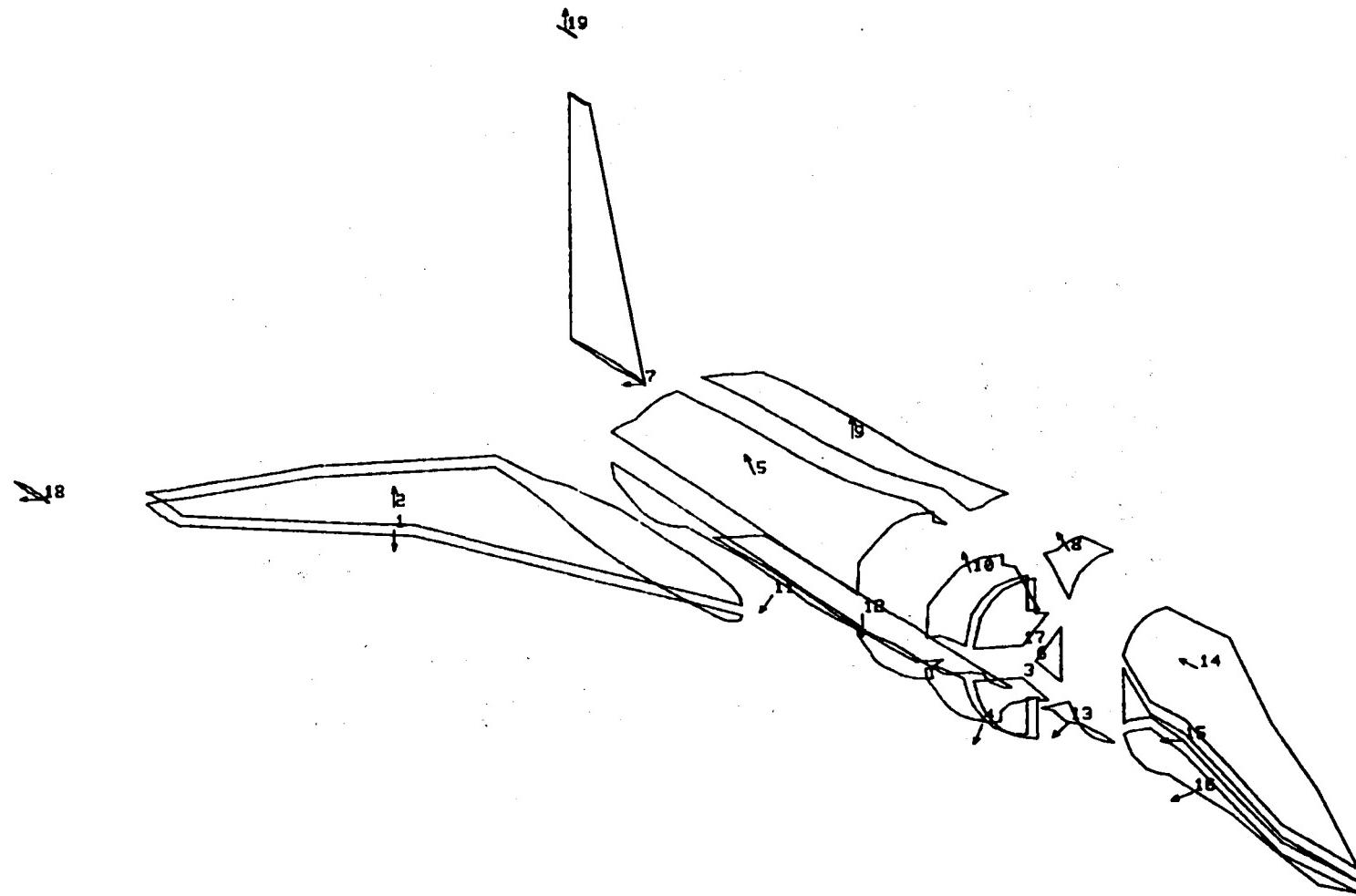
KEY IN 1 TO REDRAW 2 TO ZOOM IN
3 TO ZOOM OUT 4 TO EXPLODE
5 TO REMOVE HIDDEN LINES BATCH
6 TO RETURN TO GEOM EXECUTIVE?



(a) Normal display.

Figure 13. – Network numbers and surface normals.

KEY IN 1 TO REDRAW 2 TO ZOOM IN
 3 TO ZOOM OUT 4 TO EXPLODE
 5 TO REMOVE HIDDEN LINES BATCH
 6 TO RETURN TO GEOM EXECUTIVE?



(b) Exploded view.

Figure 13. —Concluded.

```

KEY IN 1 TO DRAW THREE VIEWS
        2 TO DRAW ORTHOGRAPHIC PROJECTION
        3 TO DRAW ARBITRARY CROSS SECTIONS
? 3

KEY IN 1 FOR SINGLE SECTION CUT
        2 FOR MULTIPLE SECTION CUTS, SINGLE PLOT FRAME
        3 FOR MULTIPLE SECTION CUTS, MULTIPLE PLOT FRAMES
? 2

DO YOU WISH A SPLINE FIT? Y OR N
? Y

INPUT TENSION FACTOR AND CUTOFF ANGLE OR "CR" TO
DEFAULT TO 1.00, 70.00 RESPECTIVELY
NOTE: MAXIMUM SPECIFIABLE CUTOFF ANGLE = 180.
?

CUTTING PLANE DEFINITION TO BE INPUT WITH THREE POINTS
1ST POINT SERVES AS THE VERTEX OF TWO VECTORS DEFINED
IN CONJUNCTION WITH POINTS TWO AND THREE.

2ND POINT FORMS VECTOR A WITH POINT ONE.

3RD POINT FORMS VECTOR B WITH POINT ONE.

NOTE: NORMAL VECTOR = A X B POINTS IN DIRECTION OF
SUBSEQUENT SECTION CUTS WITH OPTIONS 2 & 3

CONFIGURATION MINIMUM POINT X=0.          Y= 0.          Z= -.369000
CONFIGURATION MAXIMUM POINT X= 27.0740    Y= 8.80900   Z= 5.71200
ENTER X,Y,Z COORDINATES OF 1ST POINT (VERTEX)
? 5.,0.,0.

ENTER X,Y,Z COORDINATES OF 2ND POINT (VECTOR A)
? 5.,5.,0.

ENTER X,Y,Z COORDINATES OF 3RD POINT (VECTOR B)
? 5.,0.,5.

ENTER THE NUMBER OF SECTION CUTS NOT TO EXCEED 15
? 5

KEY IN 1 FOR UNIFORM SPACING BETWEEN CUTTING PLANES
        2 FOR VARIABLE SPACING BETWEEN CUTTING PLANES
? 1

INPUT THE INCREMENTAL DISTANCE BETWEEN CUTTING PLANES
? .5.

DIRECTION OF INCREASING CUTTING PLANES 1.00   I 0.      J 0.      K

DO YOU WISH TO PREVIEW PLANFORM VIEWS DETAILING YOUR
SECTION CUT LOCATIONS? Y OR N
? Y

```

Figure 14. -User responses required for display of arbitrary cross sections.

*CR TO CONTINUE

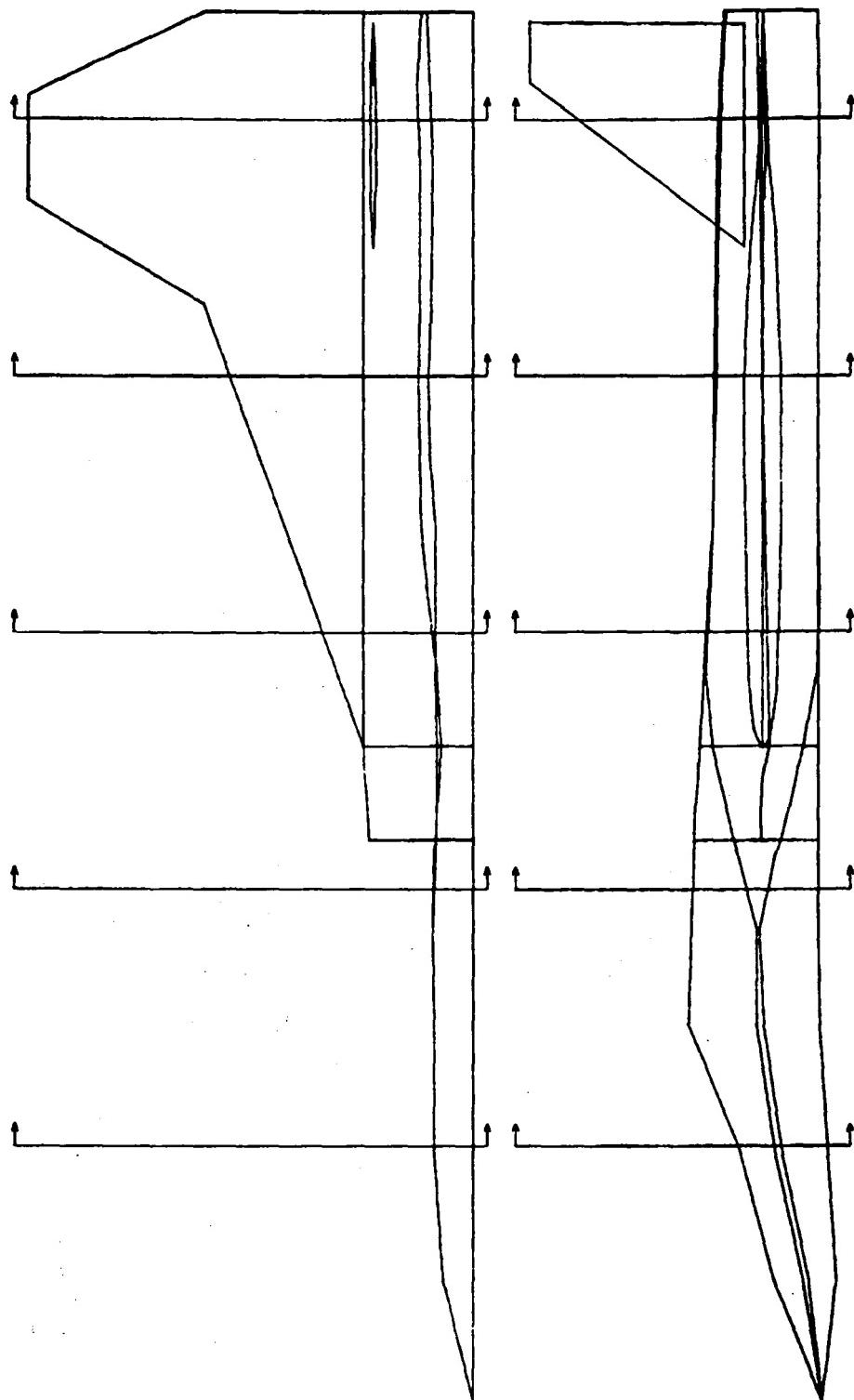


Figure 15. - Preview showing cross sections to be displayed.

CR TO CONTINUE

SECTIONS 1- 5

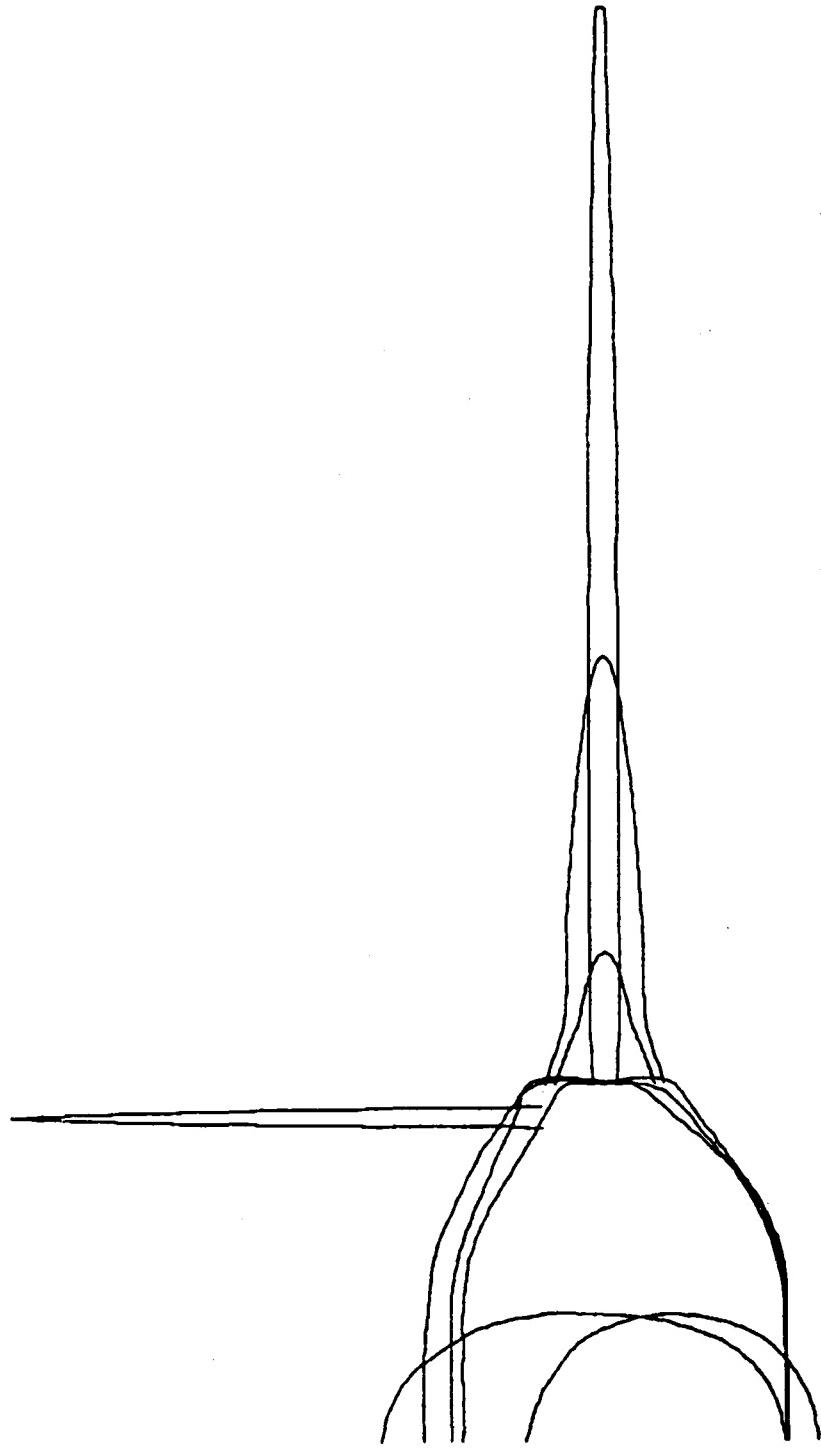


Figure 16. - Specified cross sections.

PLACE CURSOR OVER BOX
* FOR EACH OF TWO NETWORKS *
KEY IN ADJOINING EDGE NUMBER.
IE. 1,2,3,4 KEY IN Q TO QUIT

JOIN
MENU

QUIT SELECTION MODE

- 1 WING01_01
 FUS05_05
 FUS09_09
 FUS13_13
 INLT17_17

- 1 WING02_02
 INLT06_06
 INLT10_10
 FORBD14_14
 WINGTIP_18

- INLT03_03
 FIN07_07
 FUS11_11
 FORBD15_15
 FINTIP_19

- INLT04_04
 FUS08_08
 FUS12_12
 FORBD16_16

(a) Menu.

Figure 17.— Use of JOIN function.

```
KEY IN 1 TO DISCARD EDGE 1 OF NETWORK WING01..01  
       2 TO DISCARD EDGE 1 OF NETWORK WING02..02  
       3 TO DISCARD BOTH EDGES  
       4 TO KEEP BOTH EDGES  
"CR" DEFAULTS TO 4  
?  
* NETWORKS JOINED *  
INPUT NETWORK NAME UNDER WHICH YOU WISH TO SAVE  
THE JOINED GEOMETRY ?  
? WING03  
DO YOU WISH TO JOIN AGAIN? Y OR N  
ELSE RETURN TO GEOM EXECUTIVE  
?
```

(b) User responses.

Figure 17. - Concluded.

GEOM EXECUTIVE: KEY IN FUNCTION

```
CONF  ORDR  COMP  DRAW  JOIN  WAKE  CATL  SYMM  
HESS  PANR  SPLT  RPNL  NAME  STOP  
? WAKE
```

ENTERING POUTINE WAKE

BY CONVENTION, WAKES CREATED ASSUME THE "DOWNSTREAM" DIRECTION
TO BE "POSITIVE X".
NOTE: IT IS THE USERS RESPONSIBILITY TO KNOW THE NUMBER OF THE
DOWNSTREAM EDGE FROM WHICH THE WAKE WILL BE SHED!

INPUT THE VALUE OF THE WAKE "DOWNSTREAM COORDINATE"
OR "CR" TO RETURN TO GEOM EXECUTIVE
? 50.

(a) Wake downstream coordinate input.

Figure 18. – Use of WAKE function.

<p>PLACE CURSOR OVER BOX KEY IN NUMBER OF NETWORK EDGE FROM WHICH WAKE WILL BE SHED IE. 1,2,3 OR 4; Q TO QUIT!</p>			
<p>WAKE MENU</p>			
<p><input type="checkbox"/> WING01_01 <input checked="" type="checkbox"/> WING02_02 <input type="checkbox"/> INLT03_03 <input type="checkbox"/> INLT04_04</p>		<p><input type="checkbox"/> FUS05_05 <input type="checkbox"/> INLT06_06 <input type="checkbox"/> FIN07_07 <input type="checkbox"/> FUS08_08</p>	
<p><input type="checkbox"/> FUS09_09 <input type="checkbox"/> INLT10_10 <input type="checkbox"/> FUS11_11 <input type="checkbox"/> FUS12_12</p>		<p><input type="checkbox"/> FUS13_13 <input type="checkbox"/> FORBD14_14 <input type="checkbox"/> FORBD15_15 <input type="checkbox"/> FORBD16_16</p>	
<p><input type="checkbox"/> INLT17_17 <input type="checkbox"/> WINGTIP_18 <input type="checkbox"/> FINTIP_19 <input type="checkbox"/> WING03</p>		<p><input type="checkbox"/> WING02_02WKA3-----</p>	

(b) Wake menu.

Figure 18. --Concluded.

KEY IN 1 TO REDRAW 2 TO ZOOM IN
3 TO ZOOM OUT 4 TO EXPLODE
5 TO REMOVE HIDDEN LINES BATCH
6 TO RETURN TO GEOM EXECUTIVE?

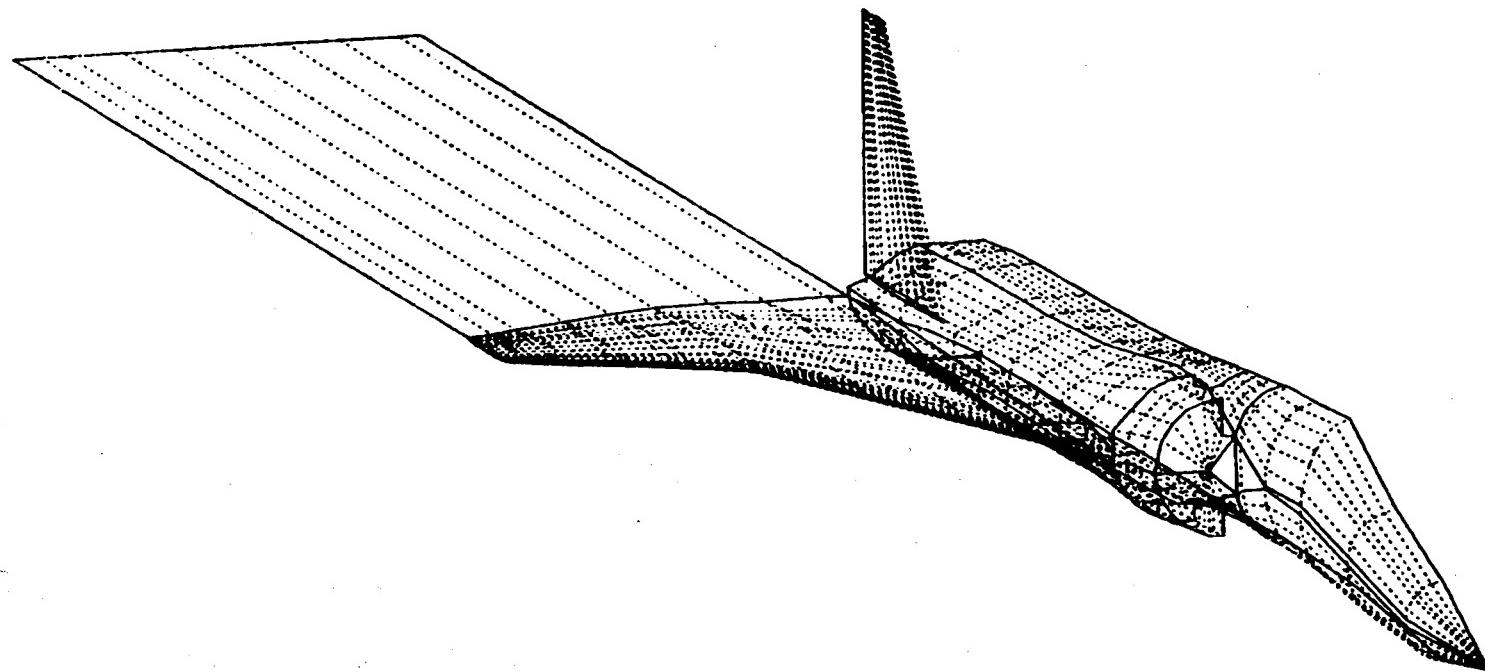


Figure 19. — Configuration with wake.

CATALOG OF PANEL DATA ON NEW FILE NEWFILE

N

CREATION DATE/TIME 83/02/28. 15.06.56.
LAST REPLACE DATE/TIME 83/02/28. 15.06.56.

NETWORK IDENTIFIER 20 CHARACTERS	ACTIVITY FLAG	COLUMNS N-LINES	ROWS M-LINES	NUMBER OF PANELS	BLOCK TYPE
WING01_01	ACTIVE	10	17	144	3
WING02_02	ACTIVE	10	17	144	3
INLT03_03	ACTIVE	2	10	9	1
INLT04_04	ACTIVE	4	10	27	1
FUS05_05	ACTIVE	10	8	63	2
INLT06_06	ACTIVE	2	2	1	1
FIN07_07	ACTIVE	2	19	18	1
FUS08_08	ACTIVE	4	?	18	1
FUS09_09	ACTIVE	10	7	54	2
INLT10_10	ACTIVE	4	8	21	1
FUS11_11	ACTIVE	10	10	81	3
FUS12_12	ACTIVE	10	7	54	2
FUS13_13	ACTIVE	4	7	18	1
FORBD14_14	ACTIVE	?	7	36	2
FORBD15_15	ACTIVE	?	2	6	1
FORBD16_16	ACTIVE	?	7	36	2
INLT17_17	ACTIVE	2	8	?	1
WINGTIP_18	ACTIVE	17	2	16	1
FINTIP_19	ACTIVE	10	2	9	1
TEMPNET580	15.07.40.	ACTIVE	10	17	144
TEMPNET950	15.07.40.	ACTIVE	10	17	144
TEMPNET786	15.07.40.	ACTIVE	2	10	9
TEMPNET297	15.07.41.	ACTIVE	4	10	27
TEMPNET453	15.07.41.	ACTIVE	10	8	63
TEMPNET006	15.07.41.	ACTIVE	2	2	1
TEMPNET275	15.07.41.	ACTIVE	2	19	18
TEMPNET305	15.07.41.	ACTIVE	4	7	18
TEMPNET689	15.07.41.	ACTIVE	10	7	54
TEMPNET382	15.07.42.	ACTIVE	4	8	21
TEMPNET132	15.07.42.	ACTIVE	10	10	81
TEMPNET831	15.07.42.	ACTIVE	10	7	54
TEMPNET582	15.07.42.	ACTIVE	4	7	18
TEMPNET098	15.07.42.	ACTIVE	7	7	36
TEMPNET276	15.07.42.	ACTIVE	7	2	6
TEMPNET620	15.07.43.	ACTIVE	7	7	36
TEMPNET083	15.07.43.	ACTIVE	2	8	?
TEMPNET990	15.07.43.	ACTIVE	17	2	16
TEMPNET979	15.07.43.	ACTIVE	10	2	9
WING03		ACTIVE	34	10	297
WING02_02UKA3_	---	ACTIVE	10	2	9
TEMPNET693	15.30.39.	ACTIVE	10	2	9
TOTAL NUMBER OF NETWORKS				41	
NUMBER OF DELETED NETWORKS				0	
NUMBER OF ACTIVE NETWORKS				41	
NETWORKS ADDED SINCE LAST REPLACE				0	
TOTAL NUMBER OF PANELS				1839	
LENGTH OF DATABASE (WORDS)				15040	
LENGTH OF BLOCK TYPE 1				64	
LENGTH OF BLOCK TYPE 2				128	
LENGTH OF BLOCK TYPE 3				256	
LENGTH OF BLOCK TYPE 4				512	
LENGTH OF BLOCK TYPE 5				1024	

CARRIAGE RETURN TO CONTINUE

Figure 20. - PAGMS file catalog.

NETWORK SELECTED FOR SPLITTING - WING03
KEY IN 1 TO SPLIT ALONG AN N-LINE
2 TO SPLIT ALONG AN M-LINE
? 1
NETWORK CONTAINS 34 N-LINES AND 10 M-LINES
LEGAL N-LINES ARE 2 - 33
INPUT SPLIT LINE
? 5
NETWORK "A" WILL CONTAIN N-LINES 1 - 5
NETWORK "B" WILL CONTAIN N-LINES 5 - 34
INPUT NETWORK NAME UNDER WHICH NETWORK "A" WILL BE SAVED.
? WING3A
INPUT NETWORK NAME UNDER WHICH NETWORK "B" WILL BE SAVED.
? WING3B
DO YOU WISH TO SPLIT AGAIN? Y OR N
ELSE RETURN TO GEOM EXECUTIVE
?

Figure 21.— Network splitting.

NETWORK SELECTED FOR RE-PANELING IS WING02..02
KEY IN 1 TO RE-PANEL THE M-DIRECTION, IE.CREATE NEW M-LINES
2 TO RE-PANEL THE N-DIRECTION, IE.CREATE NEW N-LINES
3 TO RE-PANEL BOTH THE M AND N DIRECTIONS
? 3
* RE-PANELING M-DIRECTION FIRST *
KEY IN 1 FOR UNIFORM SPACING OF M-LINES
2 FOR COSINE SPACING OF M-LINES
3 FOR USER SPECIFIED SPACING OF M-LINES
? 2
CURRENT NETWORK HAS 17 M-LINES AND 10 N-LINES
DO YOU HAVE ANY STATIONARY M-LINES, IE. M-LINES WHOSE POSITIONS
AFTER RE-PANELING REMAIN FIXED? Y OR N
NOTE: FOR COSINE SPACING, YOU NEED NOT SPECIFY LINE, 1OR 17
AS STATIONARY.
? N
0 STATIONARY M-LINES SPECIFIED
INPUT THE TOTAL NUMBER OF M-LINES TO BE IN THE RE-PANELED NETWORK
? 20
RE-PANELING IS DONE WITH SPLINES UNDER TENSION.
0.0 CUBIC SPLINE INTERPOLATION
25.0 NEARLY LINEAR INTERPOLATION (THE DEFAULT VALUE)
INPUT THE SPLINE TENSION FACTOR OR "CR" TO DEFAULT
?
* M-LINE RE-PANELING COMPLETE *
* RE-PANELING N-DIRECTION *
KEY IN 1 FOR UNIFORM SPACING OF N-LINES
2 FOR COSINE SPACING OF N-LINES
3 FOR USER SPECIFIED SPACING OF N-LINES
? 1

(a) M direction.

Figure 22. - Repanelling a network.

CURRENT NETWORK HAS 20 M-LINES AND 10 N-LINES
DO YOU HAVE ANY STATIONARY N-LINES, IE. N-LINES WHOSE POSITIONS
AFTER RE-PANELING REMAIN FIXED? Y OR N
NOTE: FOR UNIFORM SPACING, YOU NEED NOT SPECIFY LINE, 10R 10
AS STATIONARY.
? Y
INPUT NUMBERS IN FREE FORMAT. EG. 5, 3,8-6,1 3 = 3,5,6,7,8,13
OR CARRIAGE RETURN TO QUIT
? 6
1 STATIONARY N-LINES SPECIFIED
INPUT THE TOTAL NUMBER OF N-LINES TO BE IN THE RE-PANELED NETWORK
* THIS NUMBER INCLUDES 1 STATIONARY N-LINES *
? 12
RE-PANELING IS DONE WITH SPLINES UNDER TENSION.
0.0 CUBIC SPLINE INTERPOLATION
25.0 NEARLY LINEAR INTERPOLATION (THE DEFAULT VALUE)
INPUT THE SPLINE TENSION FACTOR OR "CR" TO DEFAULT
?
* N-LINE RE-PANELING COMPLETE *
DO YOU WISH TO REPLACE NETWORK WING02_02
WITH THE RE-PANELED NETWORK? Y OR N
? N
INPUT THE NETWORK IDENTIFIER UNDER WHICH YOU WISH TO SAVE
THE RE-PANELED NETWORK (NOT TO EXCEED 20 CHARACTERS).
? WING02-PEPAN
DO YOU WISH TO RE-PANEL AGAIN? Y OR N
? N

(b) N direction.

Figure 22.-Concluded.

OLD NAME = INLT04..04

INPUT NEW NAME ? INLT04

Figure 23. – Renaming a network.

YOU HAVE ELECTED TO SAVE THE 'SAUPUF' FILE.

DO YOU WISH TO POST PROCESS THIS FILE ON ONE OF
LANGLEY'S PLOTTING DEVICES? Y OR N
? Y

PLOT. CONTROL CARD DEFINITION

KEY IN 1 TO DEFAULT ALL FRAMES TO PLOT.VARIAN(Y0=1.0)
2 TO USER SPECIFY PLOT. AND CONT. CARD IMAGES
NOTE: MULTIPLE PLOT. CARD IMAGES ALLOWED
PERMITTING FRAME EDITING, ETC.

"CP" DEFAULTS TO 1
? 1

* COMPLETED *
3.703 CP SECONDS EXECUTION TIME.

----- END OF GEOM SESSION

/ENQUIRE,F

LOCAL FILE INFORMATION.

FILENAME	LENGTH/PRUS	TYPE	STATUS
INPUT*		IN.*	EOR READ
NEWFILE	225	LO.	EOR READ
OUTPUT		LO.	I/C READ
INPUT		LO.	I/C READ
DEMO	66	LO.	EOR READ
GEOABMS	1242	LO.	EOR READ
SEEPUF		LO.	EOR READ
TTINPUT		LO.	EOR READ
SAUPUF	3	LO.	EOR READ
ZZZZZ32	59	LO.	EOR WRITE

TOTAL = 10

Figure 24. - Program termination and file status after selection of STOP function.

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16. Abstract Modern aerodynamic panel methods that handle large, complex geometries have made evident the need to interactively manipulate, modify, and view such configurations. With this purpose in mind, the GEOM program has been developed. It is a menu-driven, interactive program that uses the Tektronix PLOT 10 graphics software to display geometry configurations which are characterized by an abutting set of networks. These networks are composed of quadrilateral panels which are described by the coordinates of their corners. GEOM is divided into fourteen executive-controlled functions. These functions are used to build configurations, scale and rotate networks, transpose networks defining M and N lines, graphically display selected networks, join and split networks, create wake networks, produce symmetric images of networks, repanel and rename networks, display configuration cross sections, and output network geometry in two formats. A data base management system is used to facilitate data transfers in this program. A sample session illustrating various capabilities of the code is included as a guide to program operation.			
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